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A METHOD AND AN APPARATUS FOR PURIFYING WATER BY PHOTO-CHEMICAL OXIDATION

The present invention relates to an apparatus and a method for purifying contaminated water by photochemical oxidation, wherein at least a sub-flow of water is directed through a flow channel wherein the water is irradiated with UV electromagnetic radiation from at least one UV lamp assembly.

An apparatus and a method of such kind are known from WO 99/33752. Polluted or contaminated water is discharged in large quantities, e.g. waste water from domestic residences and industries. The content of the waste water includes impurities that must be removed to a sufficient degree before the water is released to the recipient. This purification is carried out for instance in municipal cleaning installations where the contaminated water is subjected to a number of purification sub-processes for removing or eliminating the harmful effects of the impurities. The sub-processes include both biological and mechanical processes of treating the contaminated water with or without inactivating microorganisms with UV light.

The impurities may include environmentally harmful substances interfering biologically with the nature, including toxic substances and medical substances, and in particular hormone disruptive substances, such as e.g. dioxins, softeners, phthalates, and oestrogen from contraception pills. These hormonal interfering substances influence both humans, plants and animals and can cause serious genetic disorders. The known cleaning plants and methods do not particularly target these substances when purifying the contaminated water.

From US patent No. 4,792,407, an oxidation process is known for reducing the environmentally harmful substances. According to this method, ozone is "bubbled" through the water and a UV low-pressure lamp radiating monochromic light with UV energy of 253 nm wave length is used. It is found that the use of monochromic UV radiation energy with the wave length of 253 nm and with the addition of ozone as

bubbles, no creation of $OH^{\bullet}$ radicals and atomic oxygen O^{3P} will occur, as otherwise expected. This known method however is very energy consuming and it has not been possible to achieve the desired results which were expected with respect to the creation of $OH^{\bullet}$ radicals and atomic oxygen O^{3P}.

This is due to several factors. The UV low-pressure lamp with monochromic light has 100 % intensity by 253,7 nm and the 8% interval is by 184,9 nm. Firstly, this type of lamps is normally intended for inactivating microorganisms and there is hardly any or no energy at all for photochemical fission reactions of the environmentally harmful substances where the required energy most of all is within the range of between 180 nm to 220 nm.

Secondly, the wave lengths required for the photo-oxidation with molecular oxygen must be lower than 200 nm. In order to obtain sufficient energy for the photo-oxidation in water contaminated with environmentally harmful substances, a large amount of UV low-pressure lamps with monochromic light energy must be applied. This is costly and thus not cost-effective for practical use in a large scale in a contaminated water treatment plant.

Thirdly, any possible photo-oxidation, which is generated at a wave length of 184,9 nm, is prevented by using the UV low-pressure lamp, due to reflection from the UV low-pressure lamp of the radiation having other wave lengths, e.g. of 253,7 nm, or by the adjacent lamps if a multiple of lamps are installed prevents the photo-oxidation.

In e.g. U.S. patent application No. 2002/0023866 A1 is described a method of bringing bubbles of ozone in water. From WO97/29997 is known a method of disperging micro bubbles in water.

When ozone is added as bubbles in water and is radiated with monochromic UV light having a wavelength of 253,7 nm, the bubbles absorb the UV energy and oxygen and heat is created without a photo-oxidation is achieved.

The known water purification plants which are used for the oxidation process use a large amount of ozone, hydrogen peroxide and/or other oxidation means relative to the obtained cleaning effect. The reaction time is very long and a large amount of UV lamps with monochromic light must be applied. This results in that this plant is expensive in both installation and operation and the environmentally harmful, hormone affecting, disruptive substances are only partially eliminated if any elimination takes place at all.

On this background, it is an object of the invention to provide an apparatus and a method of the initially mentioned kind for purifying and eliminating or at least substantially reducing environmentally harmful substances and pharmaceutical residues in contaminated water. Other objects are to deactivate microorganisms and to eliminate or at least substantially reduce the content of contaminating hormonal interfering substances.

This object is achieved by an apparatus of the initially mentioned kind wherein said at least one UV lamp assembly includes a high-pressure UV halogen lamp which is mounted generally parallel with the flow direction in the channel; and by a method whereby the water flow is radiated with UV radiation by at least one UV halogen high-pressure lamp assembly, which is energy intensive wave lengths in the range of 150 nm to 260 nm, preferably in the range of 160 nm to 220 nm, and most preferably in the range of 192 nm to 205 nm.

By using a high-pressure UV halogen lamp, UV radiation for photochemical treatment of contaminated water is provided, wherein the radiation is within the wave length energy range adapted to decomposing hormone disruptive substances. By providing the lamps with their longitudinal direction substantially parallel to the water flow direction, the a number of lamps may be provided in the flow channel without substantially obstructing the water flow.

In the preferred embodiment of the invention, the at least one lamp assembly includes an UV absorber around the lamp. The absorber is tubular allowing the flow of water. The tubular absorber may be rectangular or cylindrical or any other suitable cross-sectional shape. Hereby, it is ensured that one lamp does not radiate light to another lamp or reflects light from another lamp. This ensures a more reliable radiation, as radiations from the lamps do not interfere with radiation from another lamp or a reflected radiation and thereby changing the wave length and thus altering the photochemical treatment of the water. The lamps may preferably be arranged in a cassette or a module which is insertable into the flow channel. The absorber is preferably made of an infrared radiation absorbing material. The absorber also ensures that infrared radiation from the surroundings interfere with the UV radiation of the UV high-pressure halogen lamp. This means that interrupting changes in temperature of the UV halogen high-pressure lamp assembly are avoided. Changes in temperature of the quartz glass of the UV halogen high-pressure lamps may result in a significant reduction in the durability of the lamp, e.g. as little as a few hundred hours.

The absorber may be made of or coated by a radiation protective material preventing decomposing of $OH^{\bullet}$ and preventing the creation of atomic oxygen O^{3P}. Apart from shielding against infrared radiation, the absorber also shields the lamp from other lamps. This reduces the creation of $OH^{\bullet}$ and atomic oxygen O^{3P} which otherwise would be created by the radiation energy in the range of 100-220 nm.

The UV absorber may be coated at least on its inner side with an absorber mass, such as e.g. Silicium Carbide SiC, which is a strong absorber of infrared energy, or Titanium oxide TiO_2 which can absorb all UV energy below 350 nm in wavelength or an absorber film of Silicium Oxide and Tinanium Oxide SiO_2-TiO_2. This absorber film will also function as a catalyst for the creation of $OH^{\bullet}$.

The lamp assembly preferably includes means for supplying a dispersion chemical to the water upstream the UV high-pressure lamp. Hereby, the dispersion of the water

with oxidation chemicals and/or combinations thereof is added immediately in front of each of the UV lamps by a jet system or the like, so that the pressure is released just before the UV halogen lamp, and a significant more effective use of the oxidation chemicals is obtained resulting in a lower use of chemicals, just as bubbles are avoided. When the oxidation chemicals are not delivered in the form of bubbles, it is no longer necessary to use large reaction containers and/or basins.

Preferably, at least one oxidation chemical is dispersed in the water. The oxidation chemical is preferably oxygen, hydrogen peroxide, ozone, perchloric acetic acid or any combination thereof. The release of the oxidation chemicals is controlled and the pressure and temperature is measured and the dispersed water is released into the water flow in such a manner that the pressure is first release at the outlet and bubbles are prevented from being created in the water around the UV halogen lamp.

The UV high-pressure lamp radiates intensive UV electromagnetic radiation with a high energy with wavelengths in the range of 150 nm to 260 nm, preferably in the range of 160 nm to 220 nm, and most preferably in the range of 192 nm to 205 nm. This results in the achievement of an efficient use of the radiated energy as each lamp is shielded from the other lamps. The UV high-pressure lamp preferably radiates the water with at least 25 mJ/cm^2, preferably at least 120 mJ/cm^2.

In the following, the invention is described with reference to an explanatory embodiment shown in the drawings, in which

Fig. 1 is a schematic side view of a flow channel with cassettes of UV-lam assemblies provided therein

Fig. 2 is a detailed side view of a lamp assembly according to the invention; and

Fig. 3 is a front view of same.

In figure 1, a flow channel 11 in a water purification system is schematically shown. In the flow channel 11, a number of lamp assemblies 10 are inserted. These lamp

assemblies are arranged in an insertable cassette or module 12. The lamp assemblies 10 comprise a halogen UV lamp 1 in a quartz tube 2 and an absorber 6 arranged around the lamp 1 and tube 2. These components are arranged on a lamp housing 3, which is mounted on a module member of the insertable cassette 12. The contaminated water flows as indicated by the arrows in the figure pass the lamp assemblies, i.e. through the tubular absorber 6 and pass the UV lamp 1 in the tube 2.

Figure 2 shows the lamp assembly 10 in more detail. As can be seen in the figure 2, the lamp assembly 10 includes a UV halogen high-pressure lamp 1 which is positioned in a quartz stem tube 2, which is mounted on a lamp housing 3. The quartz stem tube 2 is water-tightly clamped or otherwise secured to the lamp housing 3 by claming means 4. The power supply for the UV halogen high-pressure lamp 1 is established via a connection cable tube 5 in which power cables are provided. The connection cable tube 5 is sealed to the lamp housing 3 so that water is prevented from penetrating into the lamp assembly 10. The connector tube 5 may be integrally formed in the cassette module 12.

Around the UV halogen high-pressure lamp 1, an absorber 6 is provided. The absorber 6 is a tubular member wherein the lamp 1 is shielded from the radiation from other lamps. The absorber 6 absorbs the harmful wavelengths of the radiation which is radiated from the UV halogen high-pressure lamp 1 and which will cause a self-destruction of the UV lamp 1 and prevent the creation of $OH^{\bullet}$ radicals and of atomic oxygen O^{3P}. Reflections of radiation or radiations from neighbouring lamps may cause a change in temperature in the UV lamp and alter the energy-rich wavelength range of its radiation. Moreover, the infrared radiation will destroy the lamp as the lamp components will be damaged due to a temperature rise. In an "old" UV-lamp, the infrared energy radiation may be as high as 60% of the radiated energy. Without an absorber 6, this energy could be reflected back to the lamp and cause further destruction of the UV lamp 1, just as radiation from other lamps adds to the degrading of the UV lamp 1 and the quartz stem tube 2.

At the inlet of the absorber 6, a distribution nozzle 7 is arranged. Through this nozzle 7, dispersed water with oxidation means are injected into the water flow inside the absorber 6. The dispersed water including oxidation chemicals is supplied to the nozzle 7 via a supply tube 8.

Above, the invention is described with relation to a preferred embodiment. However, by the invention, it is realised that other embodiments may be carried out without departing from the scope of the invention as defined in the accompanying claims.